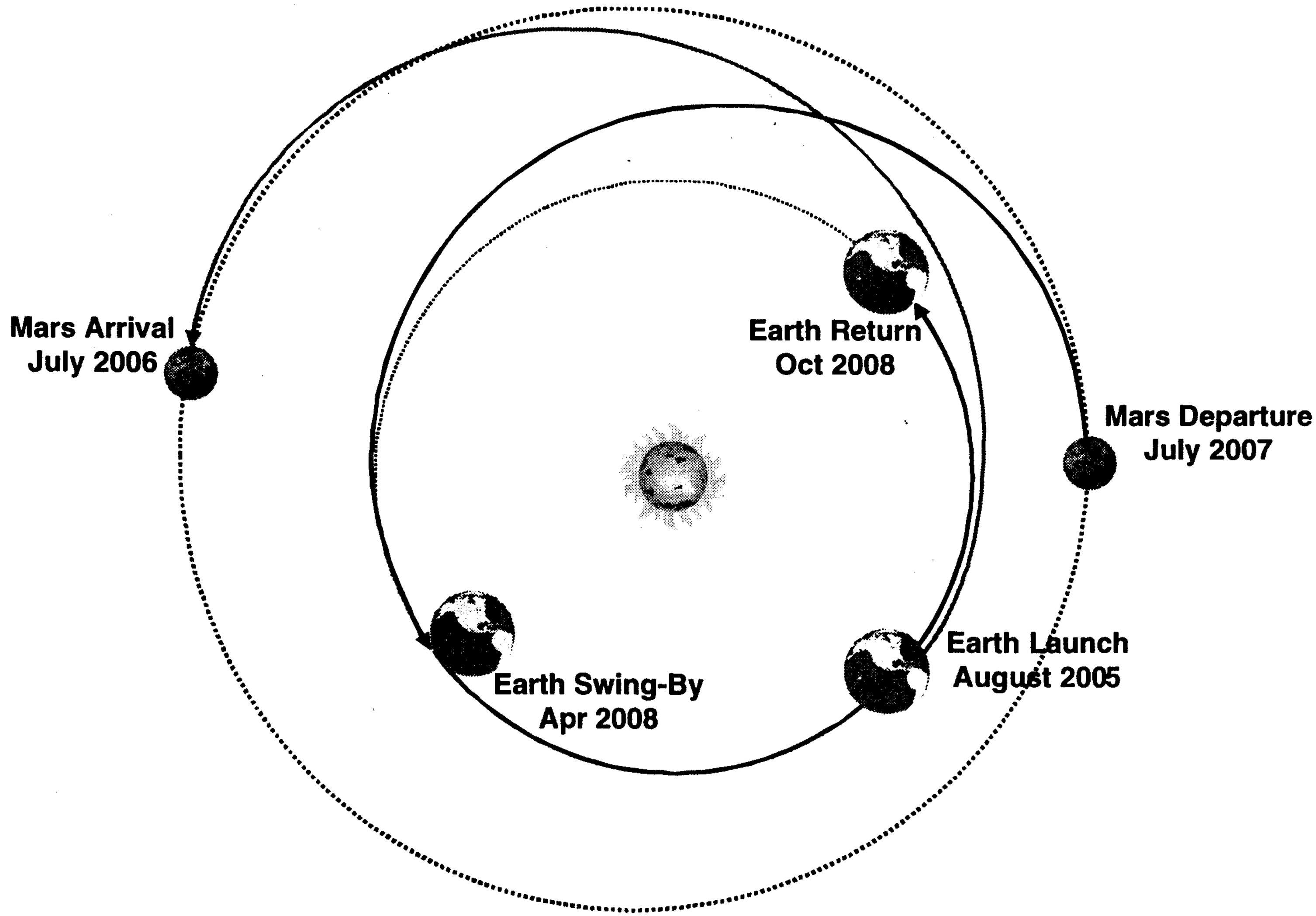
MARS SURVEYOR ARCHITECTURE
AND
PROGRAM IMPLEMENTATION PLANS

April 6, 1999

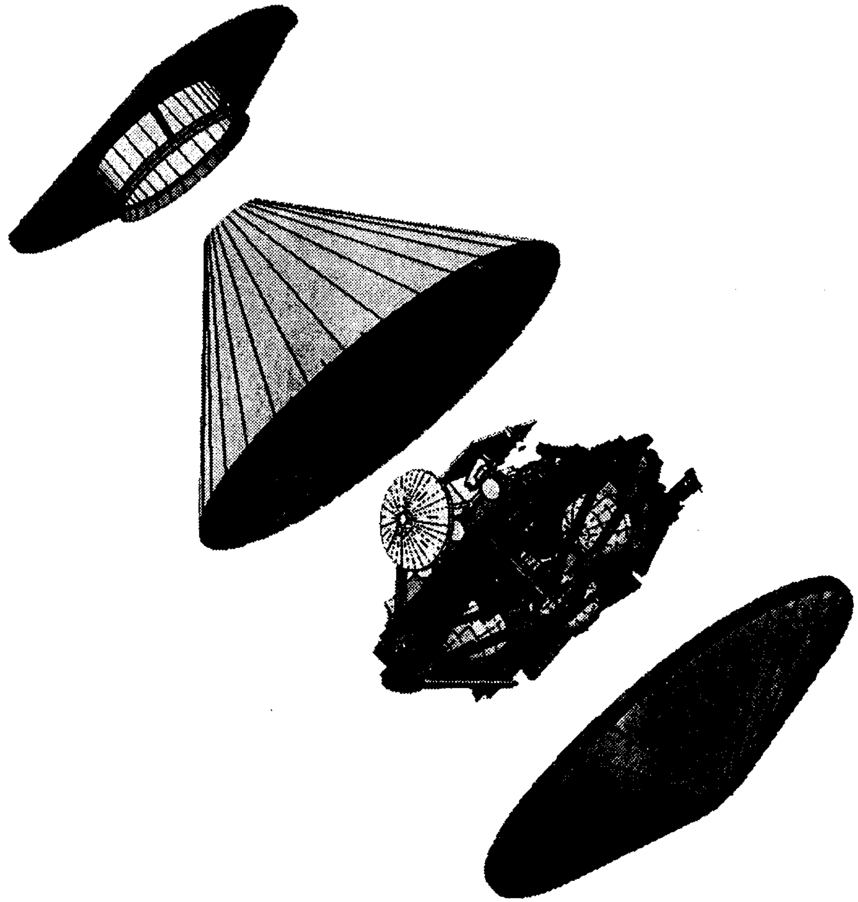
Mars Surveyor Program
Jet Propulsion Laboratory
California Institute of Technology

2005 Earth-Mars Round Trip



Lander

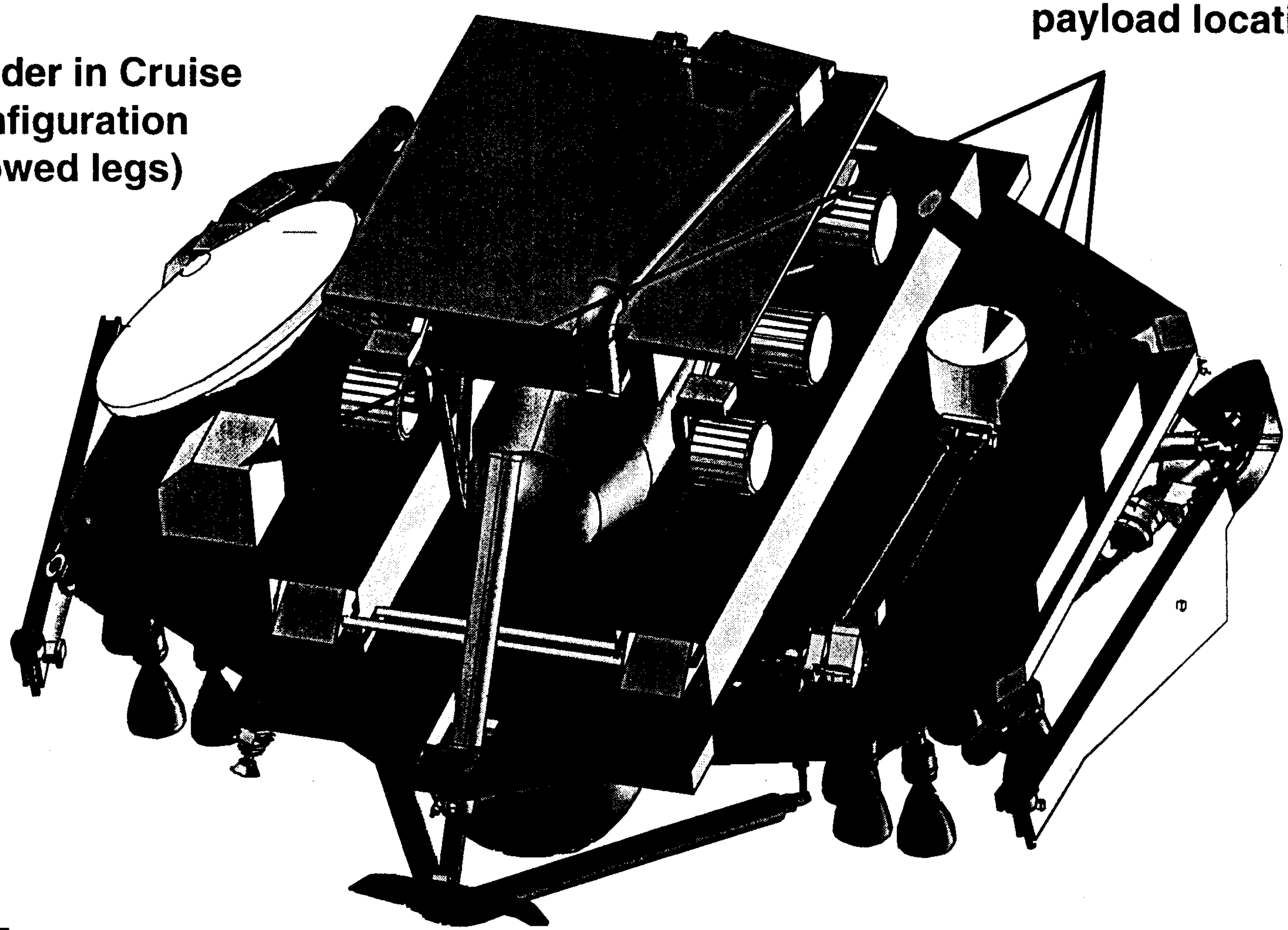
- Accurately soft lands Rover, Sample Transfer Chain, and Mars Ascent Vehicle on Mars
- 10 km accuracy
- Direct to Earth communication
- Rover - Lander comm link
- 1800 kg launch mass
- 3.65 m diameter, 2.60 m high
- Deck is 2.56 m across
- ~350 kg total payload
- Additional payloads



Mars Sample Return Project

Mars Surveyor Program

Auxiliary Payloads

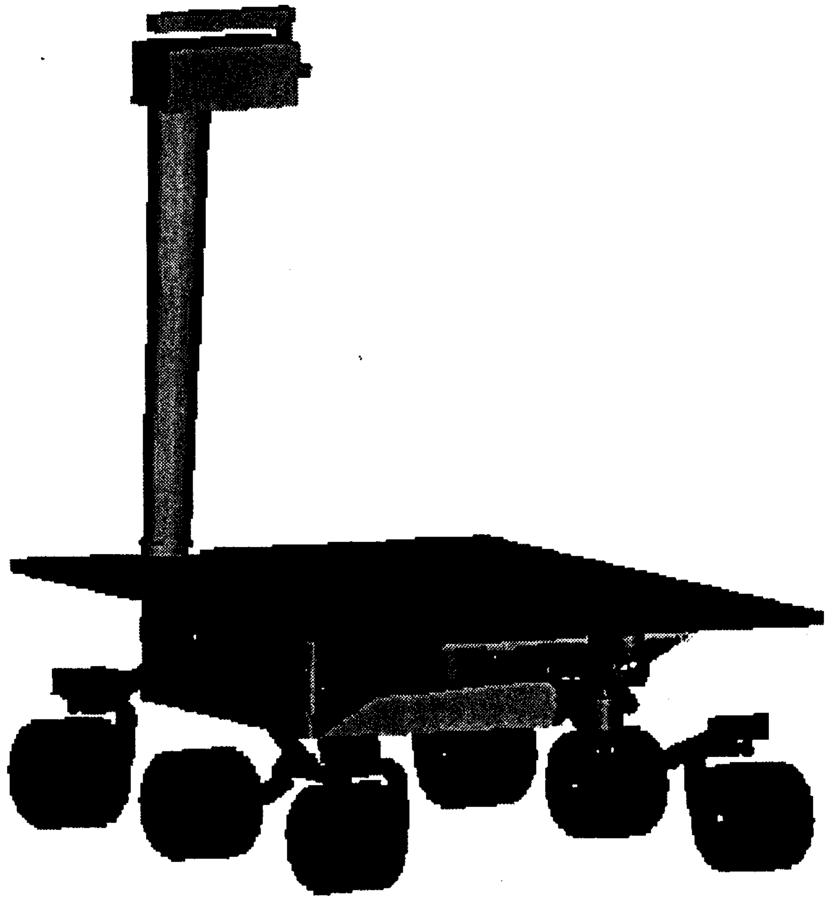


NASA JPL

cnes

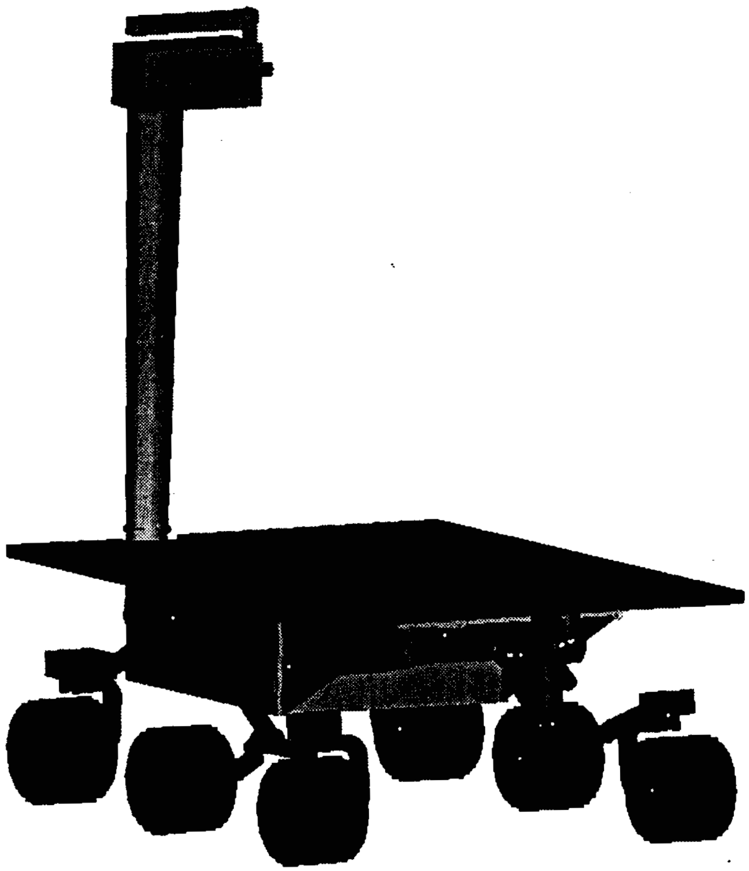
Rover

- Selection, collection, and delivery of samples
- In-situ site context science
- Athena payload:
  - Pancam + mini-TES
  - Microscopic imager
  - APXS, Mössbauer, Raman
  - Mini-corer
- ~80 kg mobile mass
- ~1.5 m in length
- ~20 sites in 3 months
- 8 x 25 mm cores (~4 g each)

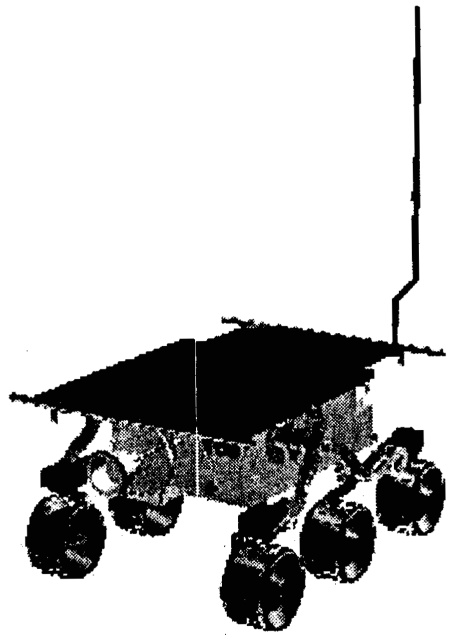


Rover Size Comparison

MSR Rover

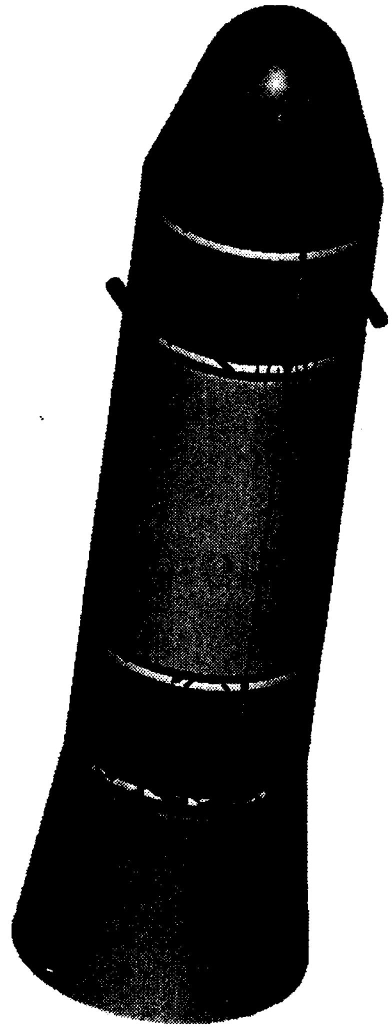


Sojourner



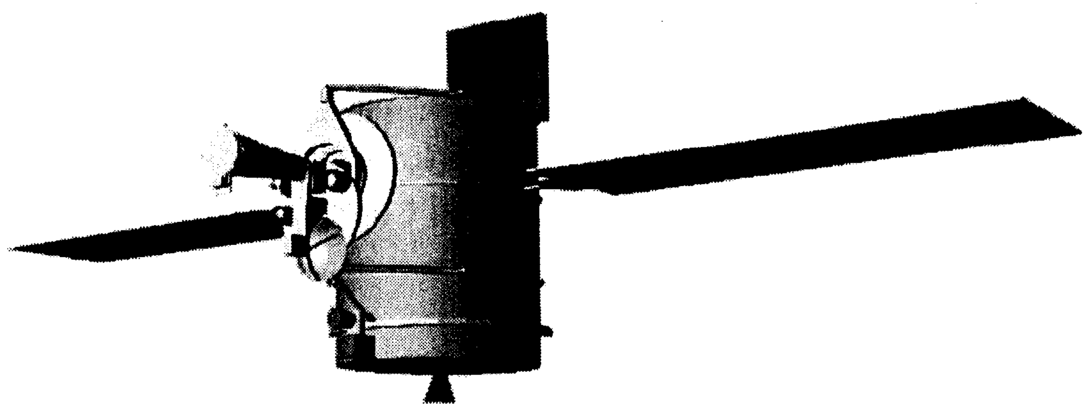
Mars Ascent Vehicle

- MAV launches the filled OS to low Mars orbit
- OS is 3.6 kg, 14 cm diameter
- Guided 1st stage, spin-stabilized 2nd and 3rd stages
- Solid rocket motors
- 145 kg system mass target
- 600±100 km altitude, 45±1° inclination orbit

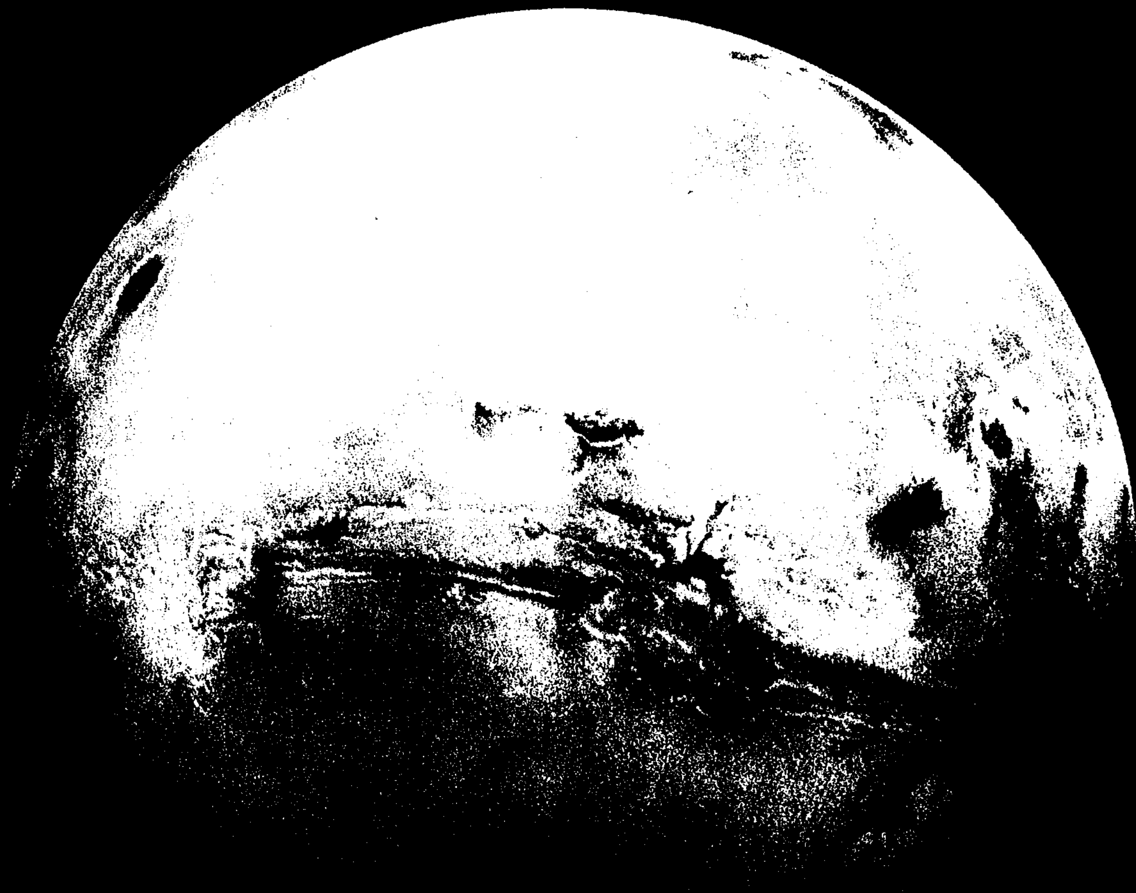


Return Orbiter

- Provided by CNES with NASA OS tracking sensors, capture devices, and Earth entry vehicle
- Aerocapture to Mars orbit + ~3.5 km/s ΔV capability
- Capable of collecting both '03 and '05 Orbiting Samples
- Carries four Netlanders deployed before arrival at Mars
- 2700 kg launch mass, including Netlanders



Mars Surveyor Program Architecture Update



by
J. F. Jordan

Mar 2, 1999

A New Mars Surveyor Program Architecture

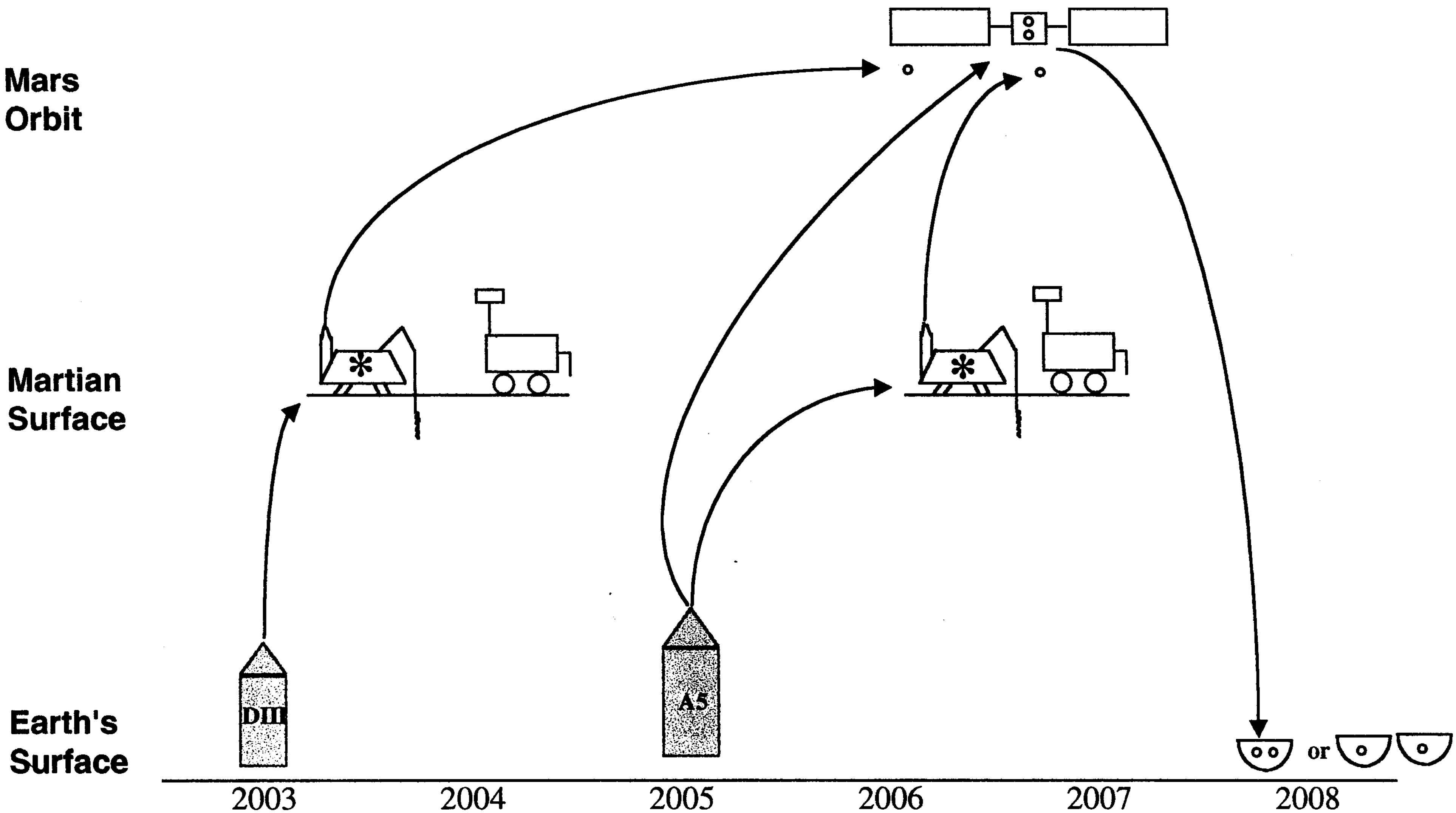
- Created in summer of 1998
- Definition Team assembled at JPL
  - International participants
- Presented to
  - NASA administrator
  - U.S. scientific advisory groups
  - National space agencies

Definition Study Summary Result

SOLAR SYSTEM EXPLORATION

- Begin in 2003
  - Mars Sample Return missions
  - Complimentary small science missions
  - Establish a Mars-orbiting telecommunications infrastructure
  - Host experiments which further the preparation for human exploration
    - Environmental characterization
    - Technology demonstrations
  - International partnerships

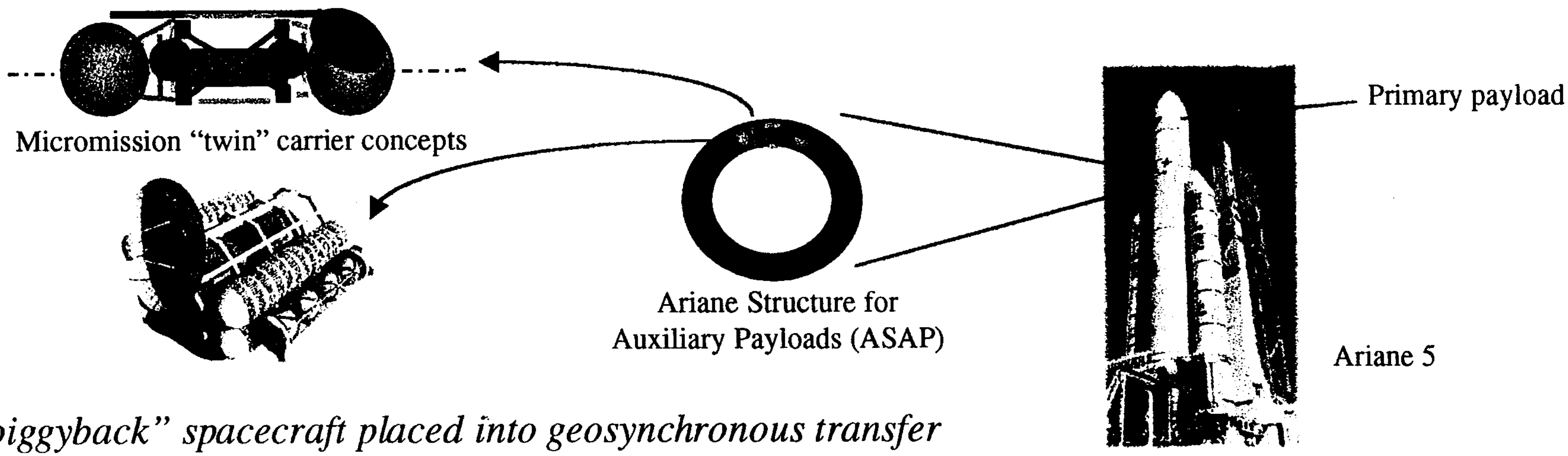
Mars Surveyor Proposed Architecture
2003, 2005 Opportunities



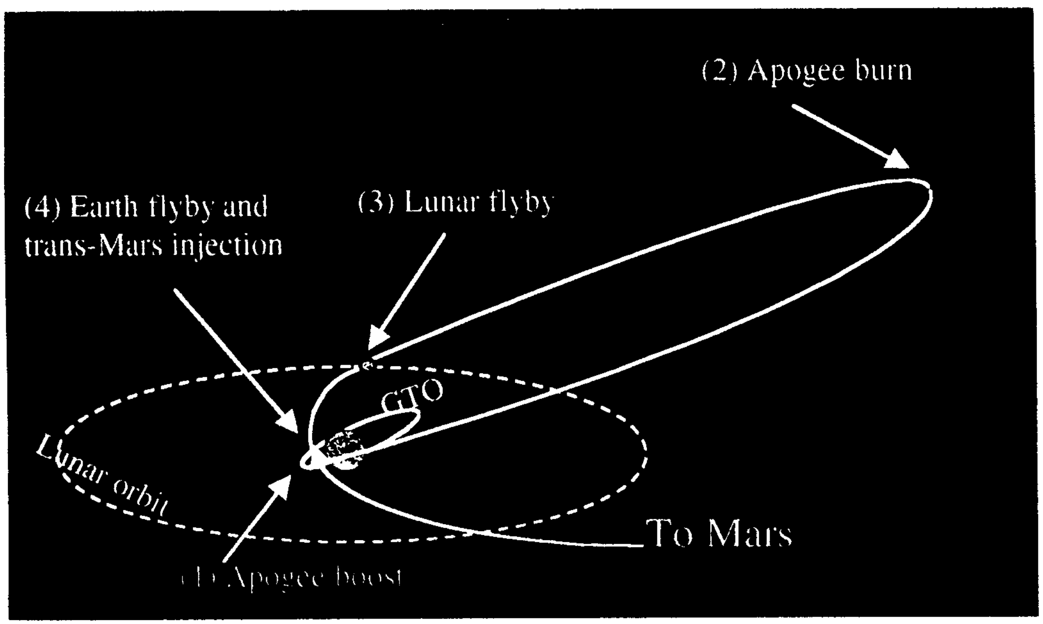
DIII = Delta 3 class vehicle (Delta 3, Atlas 3A, H2, etc.)

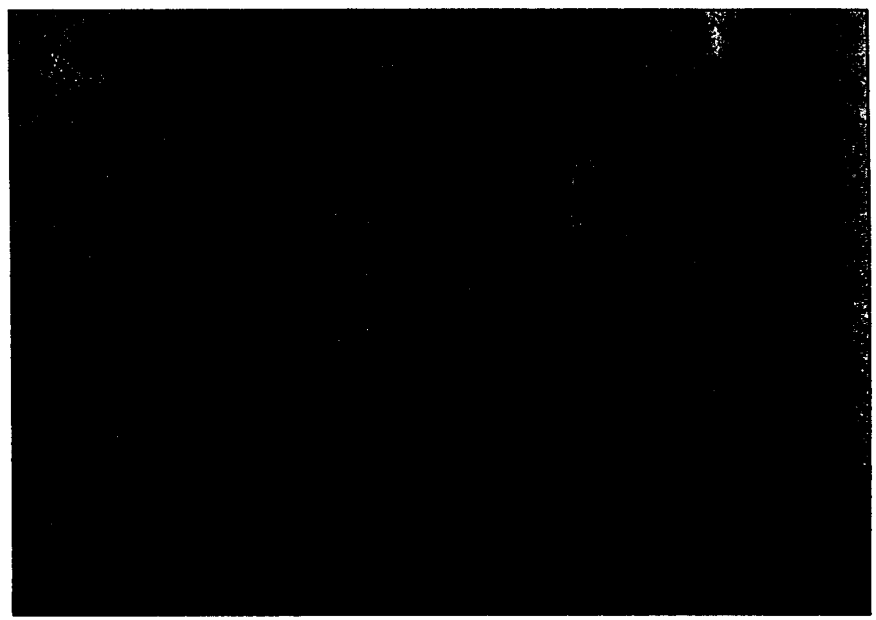
*** = Includes TBD mass for drill, arm and experiments in addition to rover and mini MAV**

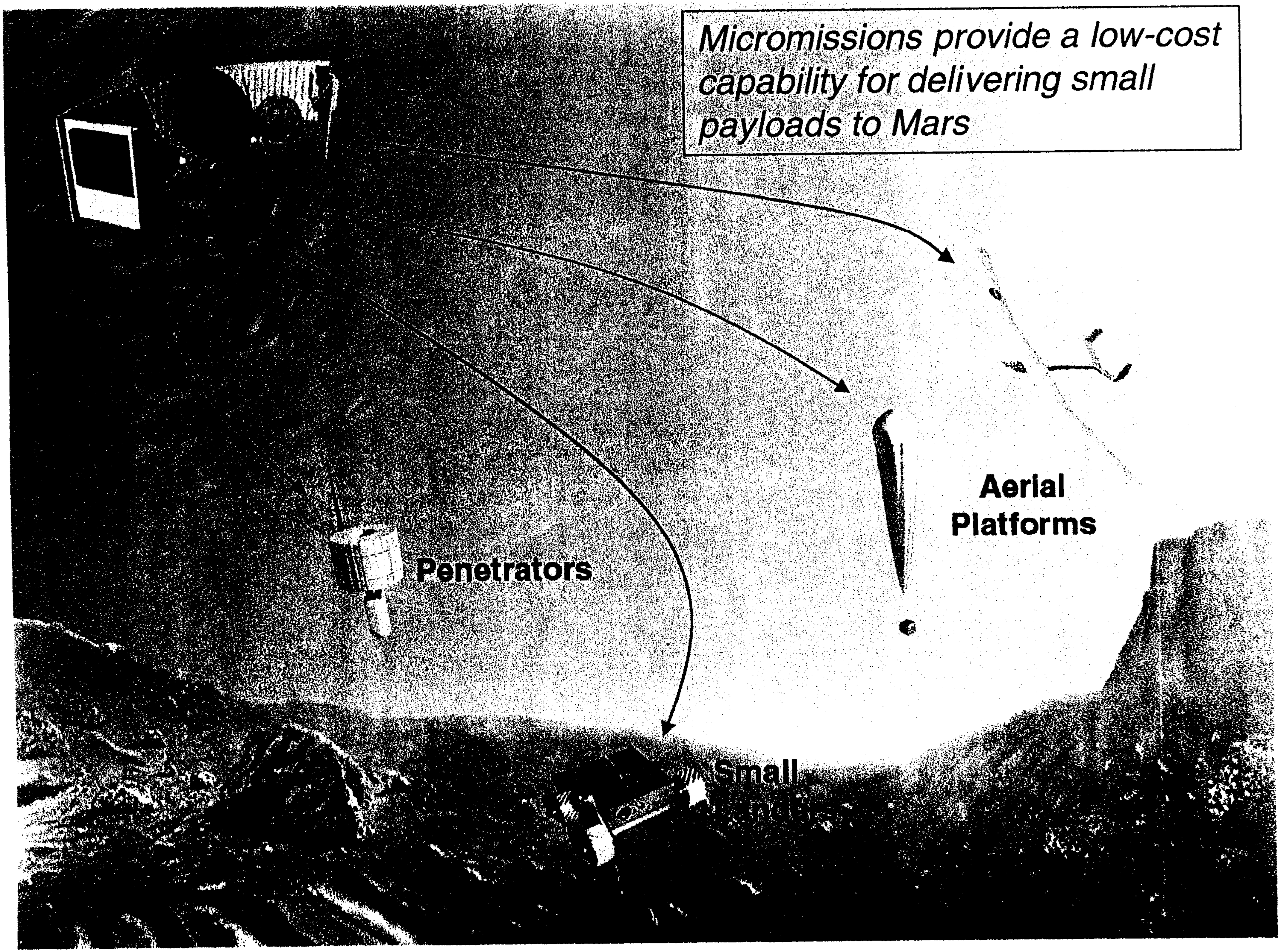
Mars Micromissions Using Ariane 5



Small "piggyback" spacecraft placed into geosynchronous transfer orbit (GTO) by Ariane 5 can travel independently to Mars






Micromissions provide a low-cost capability for delivering small payloads to Mars
Aerial Platforms
Penetrators
Small

Potential International Partnerships

(for Multiple Opportunities, Unless Otherwise Noted)

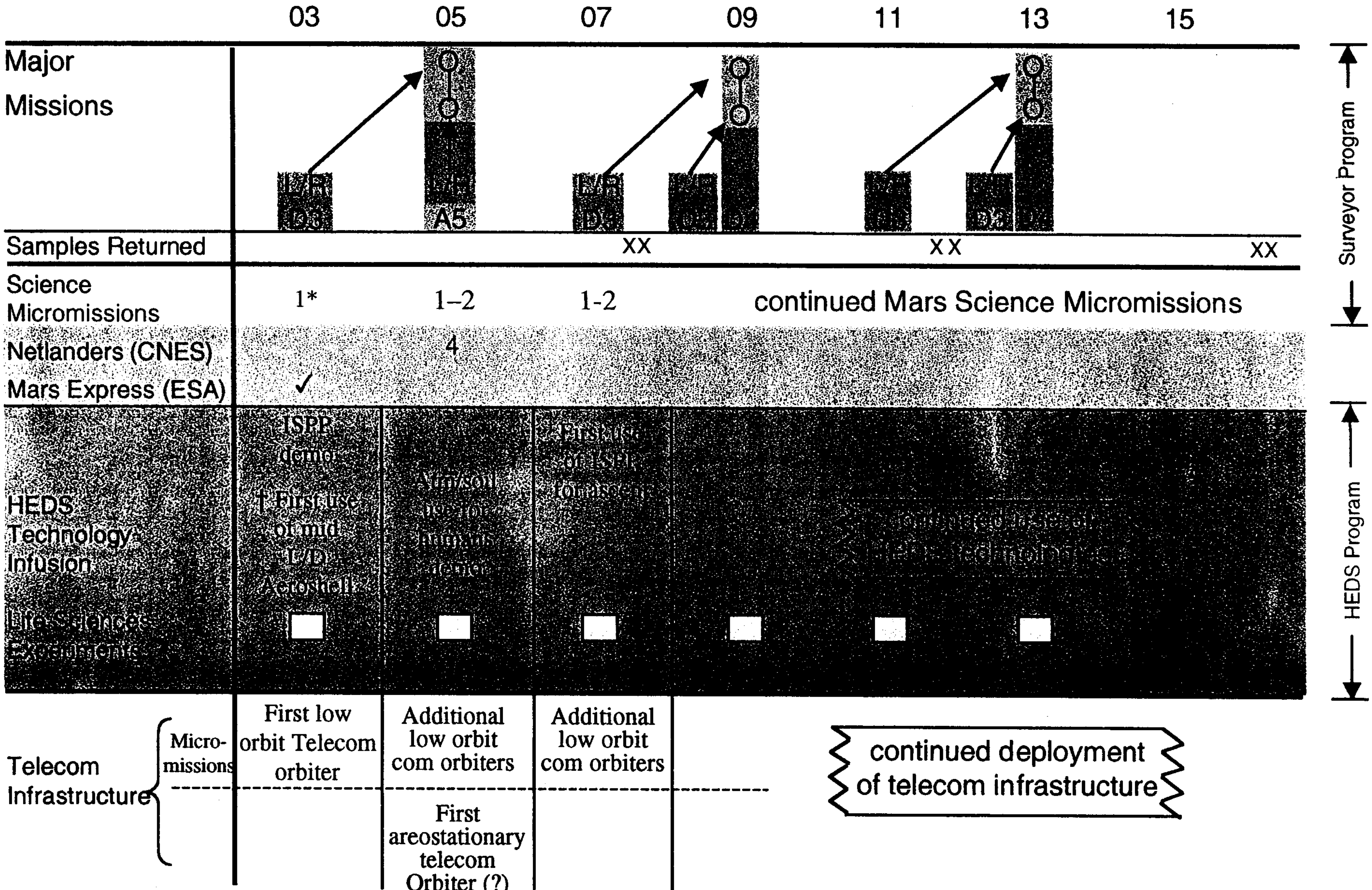
- NASA provides:
  - Lander, Rover, Mars Ascent Vehicle, Rendezvous and Docking Equipment, Earth Entry Capsule, beginning in 2003
  - Delta 3/4 Class Launch Vehicles, beginning in 2003
  - Micromission Bus, beginning in 2003

- ASI provides:
  - Drill and other robotic elements for landers, beginning in 2003
  - Relay telecom on Mars Express and Mars Express operations
    - Possible sample canister locating and positioning in 2004
  - Radar sounding experiment on Mars Express

- CNES provides:
  - Orbiter, capable of bringing two samples back to Earth, beginning in 2005
  - Ariane 5 Launch Vehicle in 2005 only
  - Ariane Piggyback launches to GTO, beginning in 2003
  - NetLanders in 2005

- ESA provides:
  - Mars Express Orbiter in 2003
  - Possible sample canister locating and positioning in 2004
  - Possible landed science package (Beagle II)

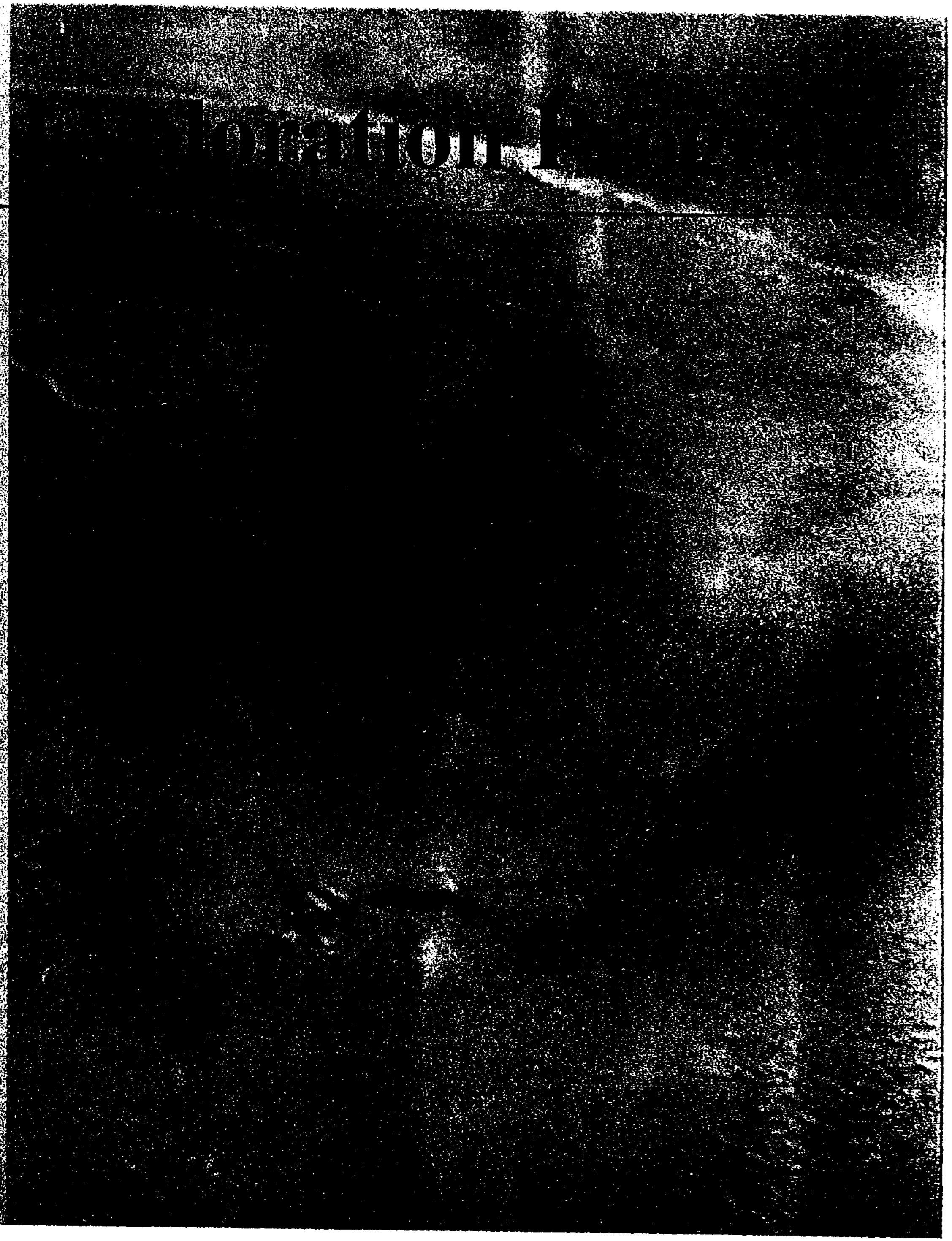
Proposed Integrated Architecture



D3 = Delta 3 class vehicle (Delta 3, Atlas 3A, H2, etc.)

* = budget challenge for aircraft
† = needs decision

Mars Exploration Program



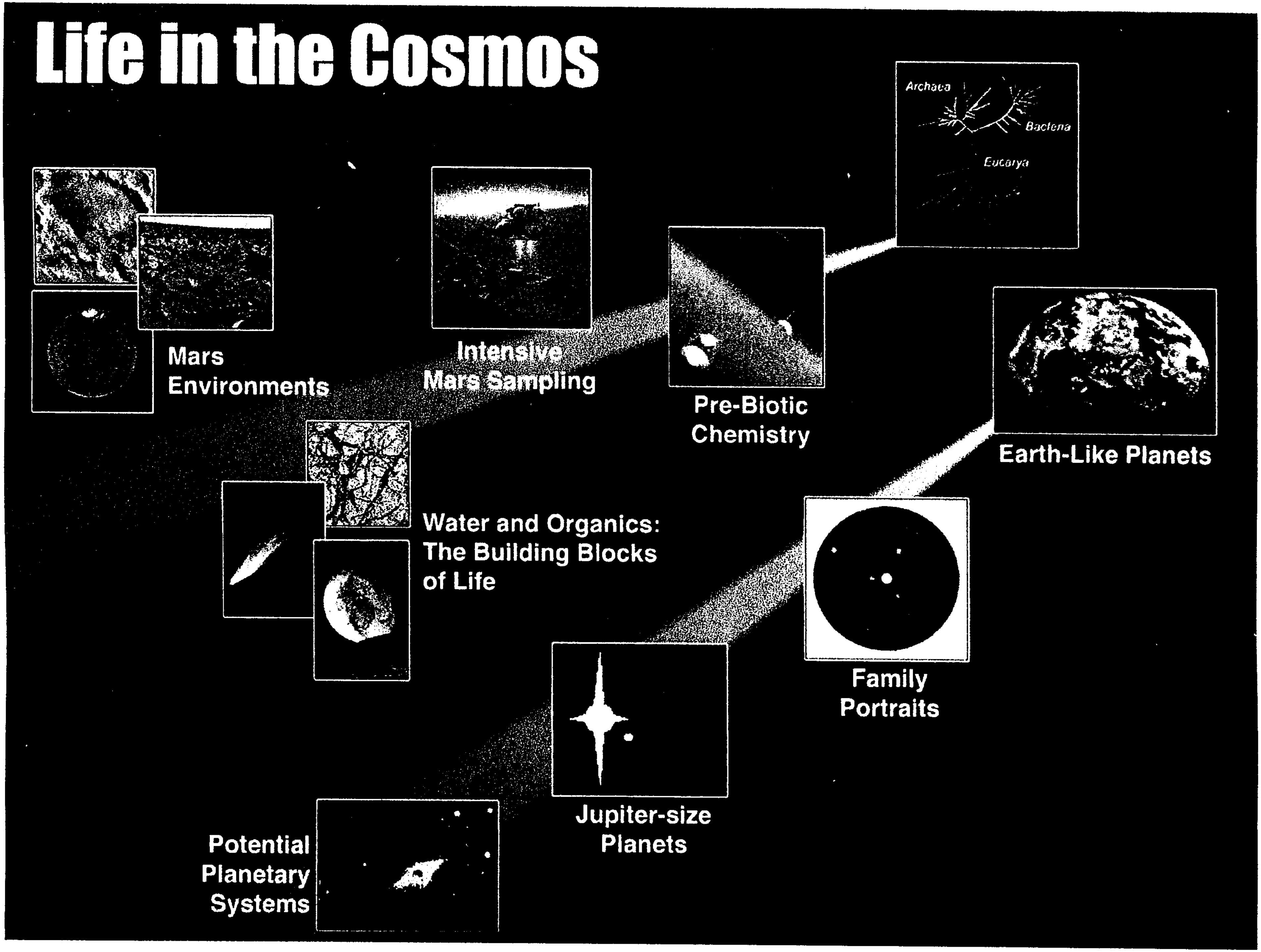
Report of the Architecture Team

Charles Elachi,
Chair

Presentation to the Office of Space Science

Ed Weiler,
Associate Administrator

April 6, 1999


Life in the Cosmos
Archaea
Bacteria
Eucarya
Mars Environments
Intensive Mars Sampling
Pre-Biotic Chemistry
Earth-Like Planets
Water and Organics: The Building Blocks of Life
Family Portraits
Jupiter-size Planets
Potential Planetary Systems

Mars Exploration

The Common Thread

Primary Goals

Resulting Knowledge

W A T E R

When
Where
Form
Amount

LIFE — Evidence of Life: Past or Present

Understand the Potential for Life Elsewhere in the Universe

Understand the Relationship to Earth's Climate Change Processes

RESOURCES — Environment & Utilization

Understand the Solid Planet: How It Evolved and Its Resources for Future Exploration

The Search for Life on Mars

Recommendation of the Mars Expeditions Working Group:

"The search for life on Mars should be directed at ... (three) environments ... most favorable to ... life."

- Ancient groundwater environments
- Ancient surface water environments
- Modern groundwater environments

Mars Exploration Program (1996-2001)

Launch Dates:

1996	1998	2001	2003	2005	2007	2009
Geology & Geophysics	*Water, Volatiles & Climate*	*Elemental Composition & Global Mineralogy*	*Geology & Mineralogy*			
[illegible]	[illegible]	[illegible]	Mars Express (ESA/ASI)			
Lander Technologies; Microrover	*Analyze Subsurface Ice*	*Survey Conditions for Human Exploration*			TBD	
Mars Pathfinder	[illegible] DS-2 Microprobes	[illegible]				
	Interaction with Solar Environment					
	Nozomi (Japan)					

● = NASA Mars Surveyor Program ○ = NASA Discovery Program ● = NASA New Millennium Program ○ = International Missions

Vision for 2020: Objectives

The Mars Surveyor Program is a key element of the NASA Origins Program, which has as one of its goals to further our understanding of the origin and evolution of life in the universe in general, and in our solar system in particular.

The primary objective of the Mars Surveyor Program is to further our understanding of the biological potential and possible biological history of Mars, and to search for indicators of past and/or present life there.

A complementary objective is to improve our understanding of Mars' climate evolution and planetary history, and to identify the best locations for future long-term scientific bases

A further objective is to demonstrate technology and acquire data necessary for future human exploration of Mars.

Vision for 2020: Approach

The Mars Surveyor Program will:

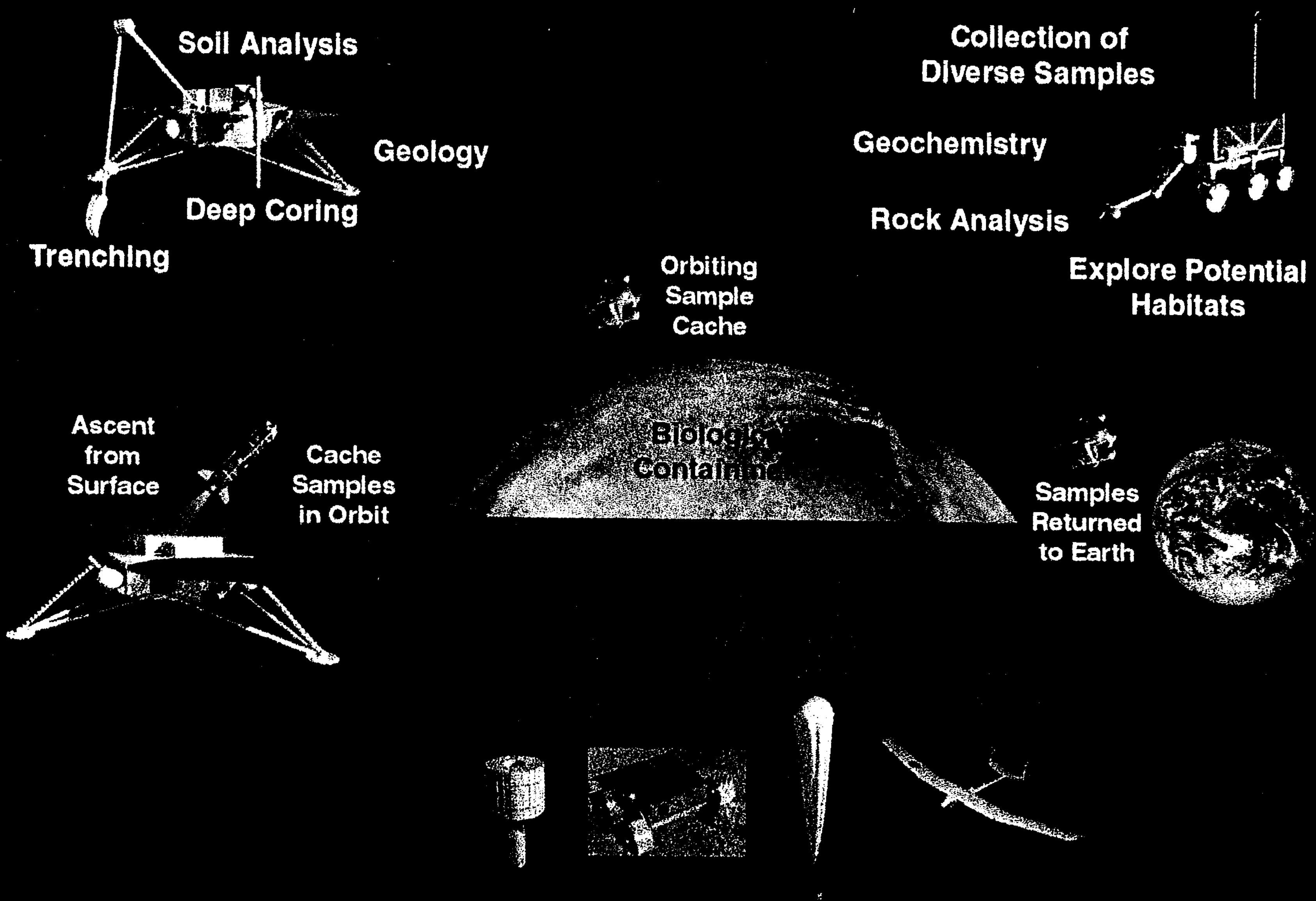
1) Conduct focused in-situ analyses at a number of carefully selected sites, and return samples from these sites for more detailed analysis in Earth laboratories. These analyses will address the following questions:

   - Do Martian materials contain evidence of former Martian life?
   - What were past environmental conditions on Mars, and how have they changed with time?
   - What is the best strategy for searching for extant Martian life?

2) Develop and test technologies that will improve the performance and reduce the cost of future robotic and human Mars missions.

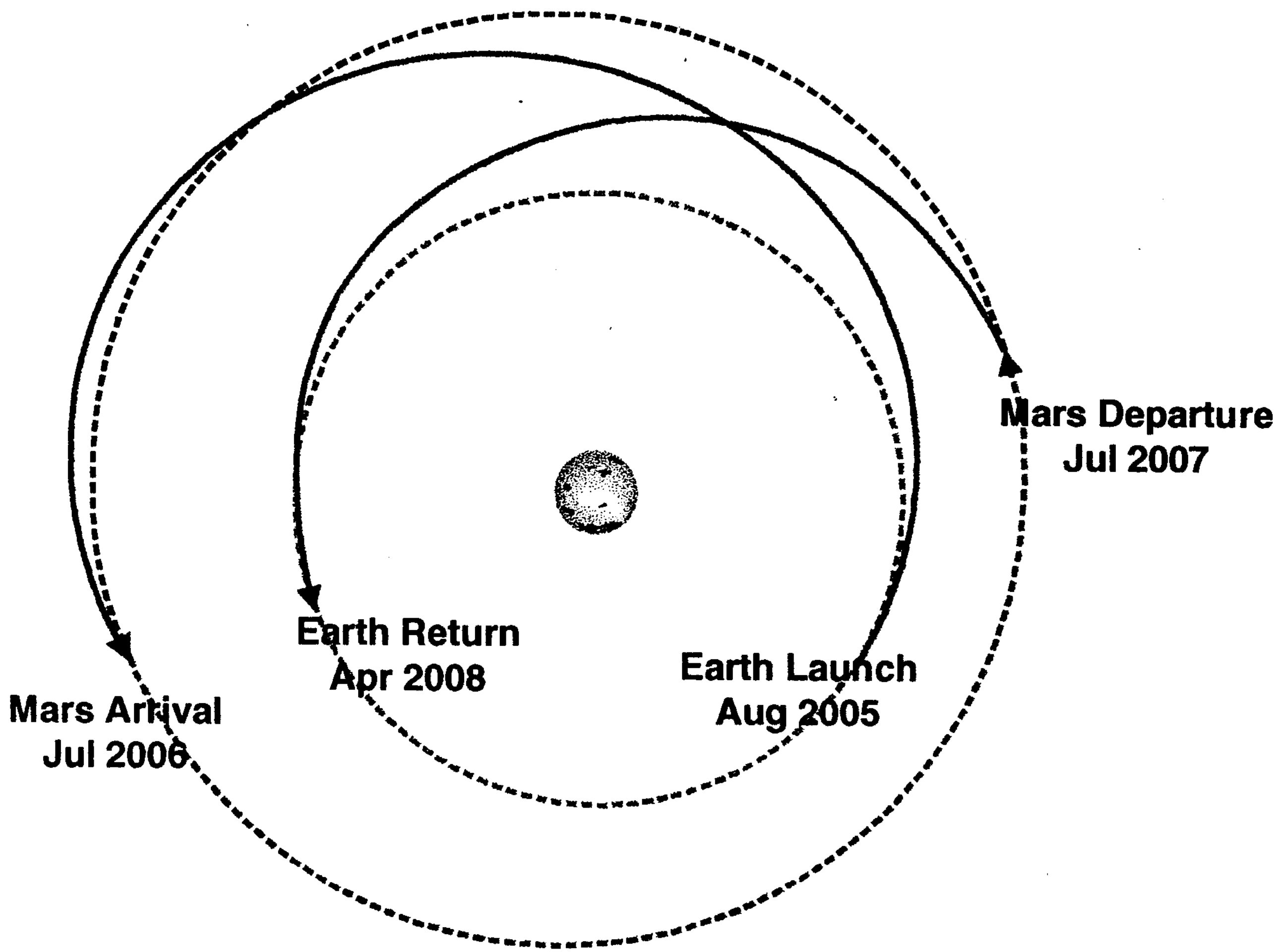
The selection, acquisition, and in-situ analyses of samples will be done with sophisticated robotic laboratories. However, subsequent more extensive capability will probably require human presence.

Tools for Exploring Mars



The Road To Mars And Back

Example: 2005 Opportunity

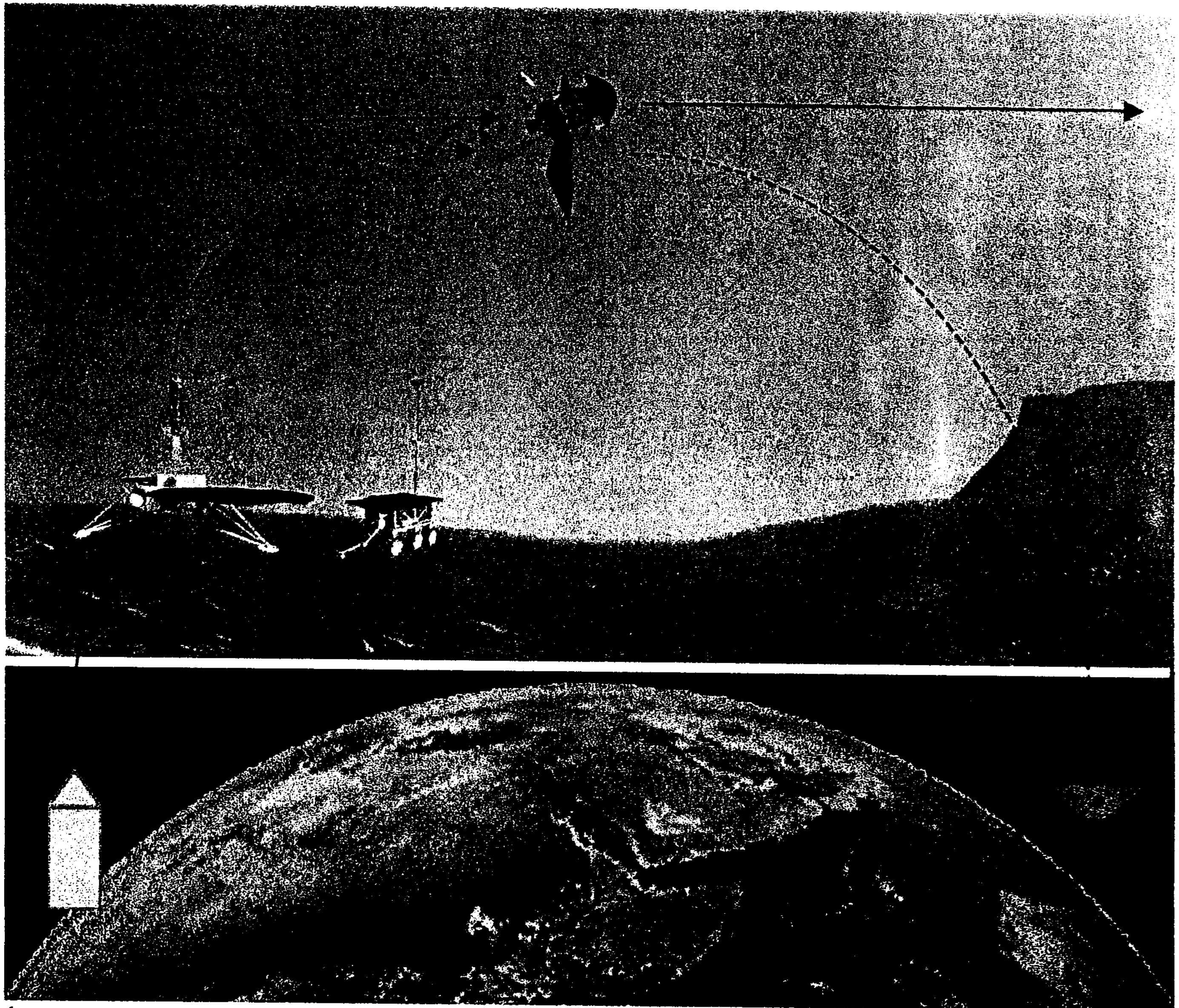


Mars Sample Return

Mars Orbit

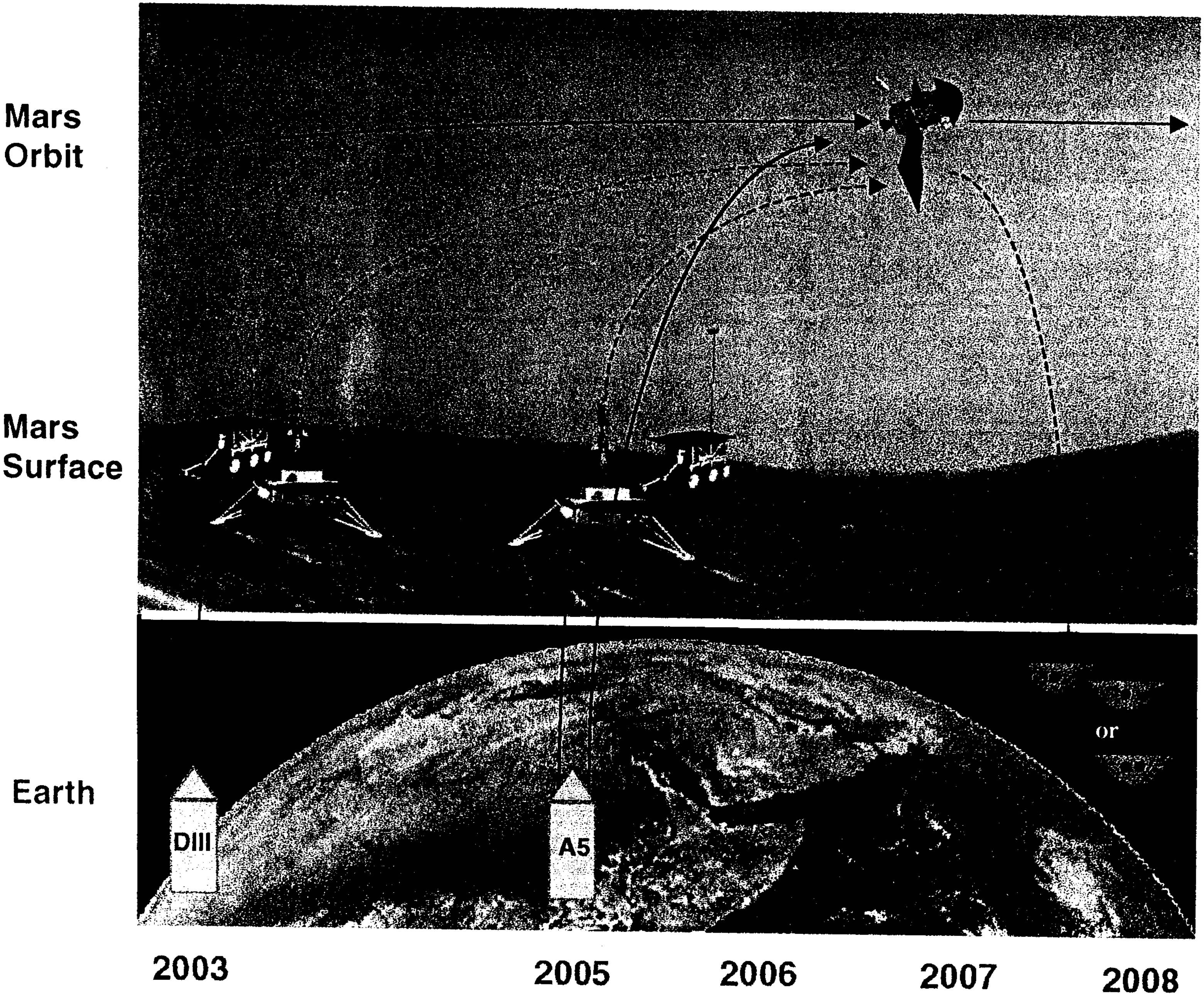
Martian Surface

Earth Surface



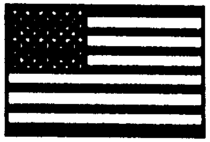
~3 years

Mars Sample Return Missions: 2003, 2005 Opportunities



U.S./France International Partnership

(for Multiple Opportunities, Unless Otherwise Noted)



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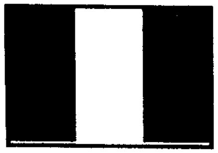

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  - Orbiter, capable of bringing two samples back to Earth, beginning in 2005
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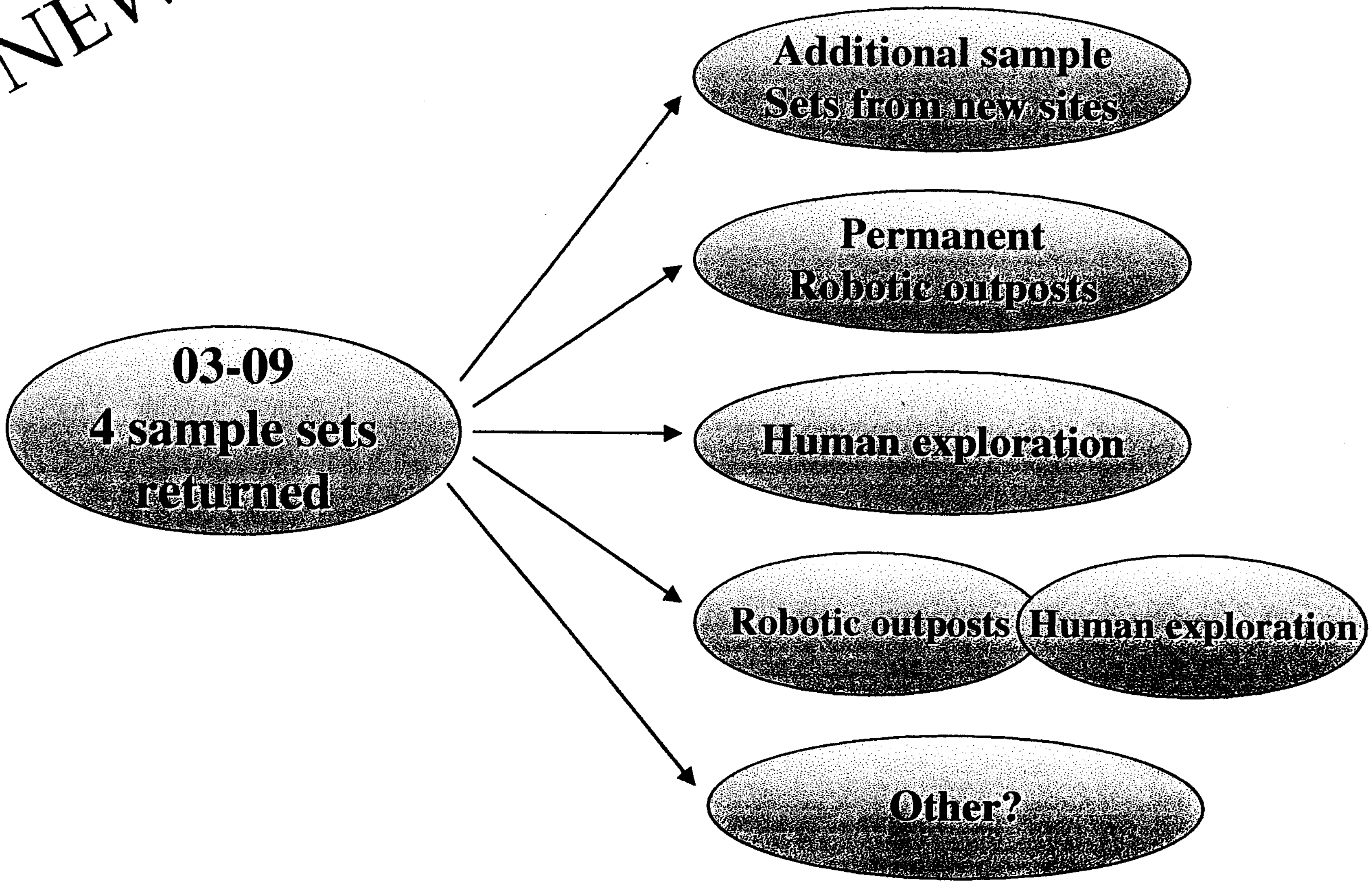
  - NetLanders in 2005

Additional International Contributions

- ASI provides:
  - Drill and other robotic elements for landers, beginning in 2003
  - Relay telecom on Mars Express and Mars Express operations
- ESA provides:
  - Mars Express Orbiter in 2003
  - Sample canister detection, sighting, and orbit determination in 2004 (using telecom and DLR high-resolution, stereo camera)

Long Term Options

NEW

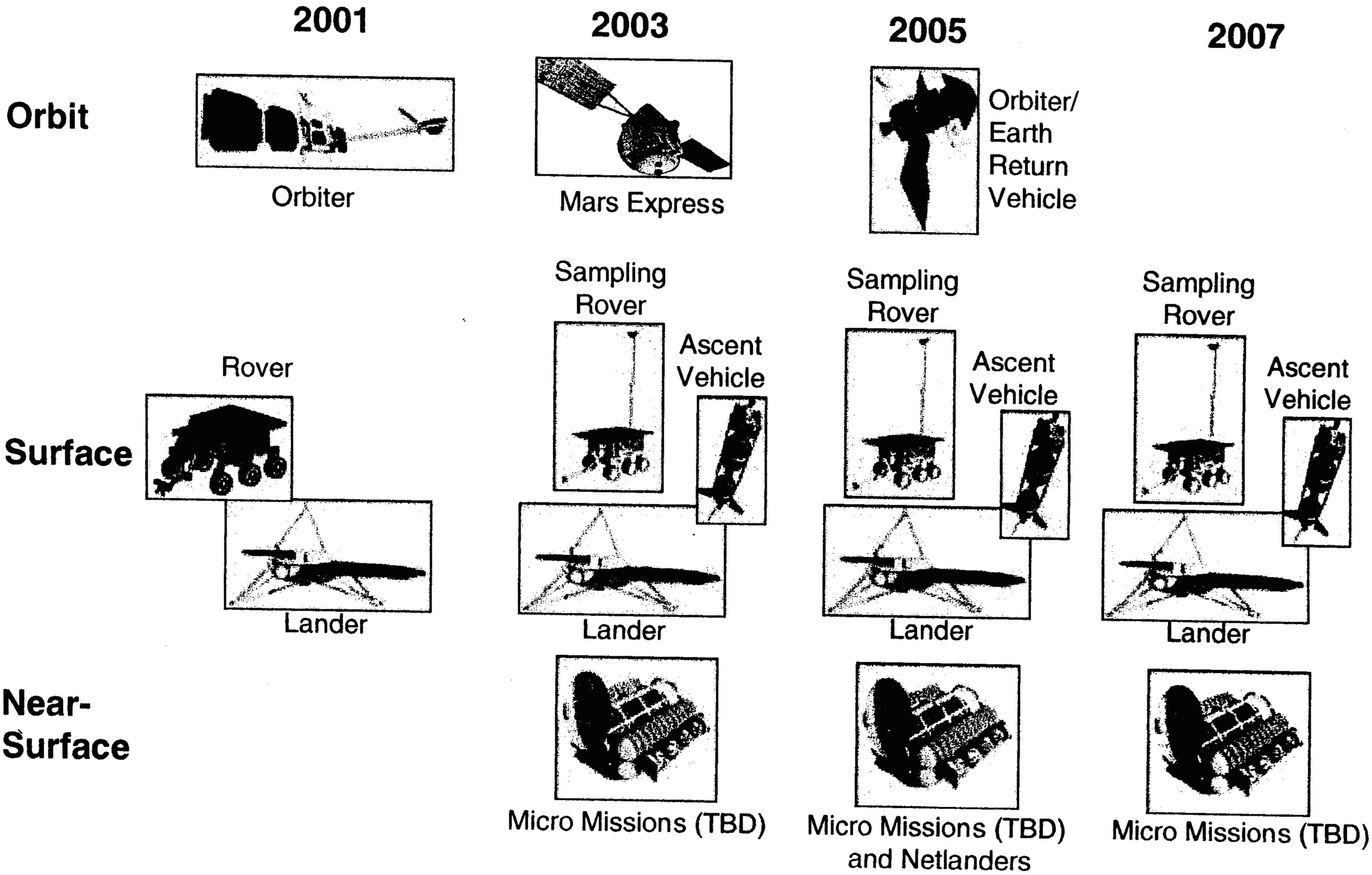


Mars Exploration Proposed Architecture

SOLAR SYSTEM EXPLORATION

Launch Dates:	2003	2005	2007	2009	2011	2013
		Retrieval & Return to Earth of '03 and '05 Samples		*Retrieval & Return to Earth of '07 and '09 Samples*		*Retrieval & Return to Earth of '11 and '13 Samples*
	Mars Express (ESA/ASI)	**Sample Return Orbiter (CNES)**		**Sample Return Orbiter (CNES)**		**Sample Return Orbiter (CNES)**
	Sample Evaluation, Collection & Transfer to Orbit	*Sample Evaluation, Collection & Transfer to Orbit*	*Sample Evaluation, Collection & Transfer to Orbit*	*Sample Evaluation, Collection & Transfer to Orbit*	*Sample Evaluation, Collection & Transfer to Orbit*	*Sample Evaluation, Collection & Transfer to Orbit*
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Addtional Science/Tech Experiments	**Addtional Science/Tech Experiments** →				
	Micromissions (1?) (CNES/NASA)	**Micromissions (2) (CNES/NASA)**	**Micromissions (2) (CNES/NASA)**			
		NetLanders (4) (CNES)				
	Telecom (1)	**Telecom (2)** →				

Mars Exploration Program Architecture

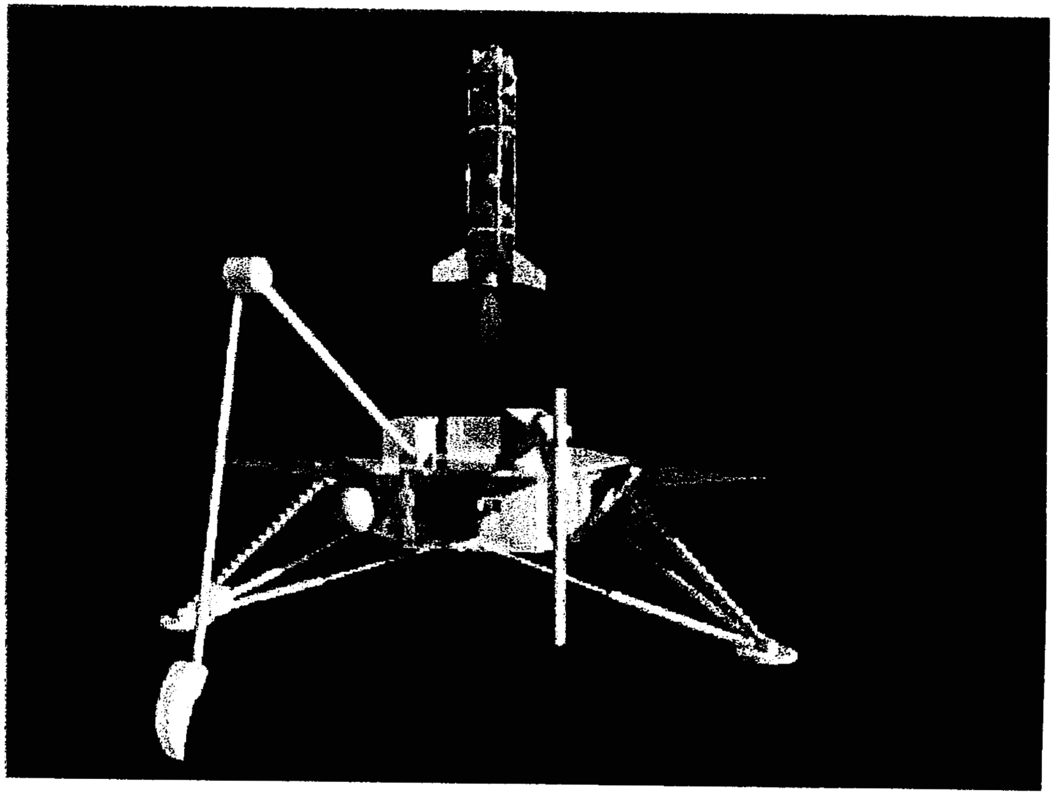


Lander

- "Workhorse lander" for sampling missions (2003, 2005, others TBD)
- Carries and deploys sampling rover and relays rover communications
- Carrier and launch pad for mini-MAV
- *In-situ* science capability ... instruments TBD
- Platform for possible subsurface drill or coring device
- Sample acquisition system for *in-situ* science and contingency samples
- Sample transfer chain from rover to mini-MAV

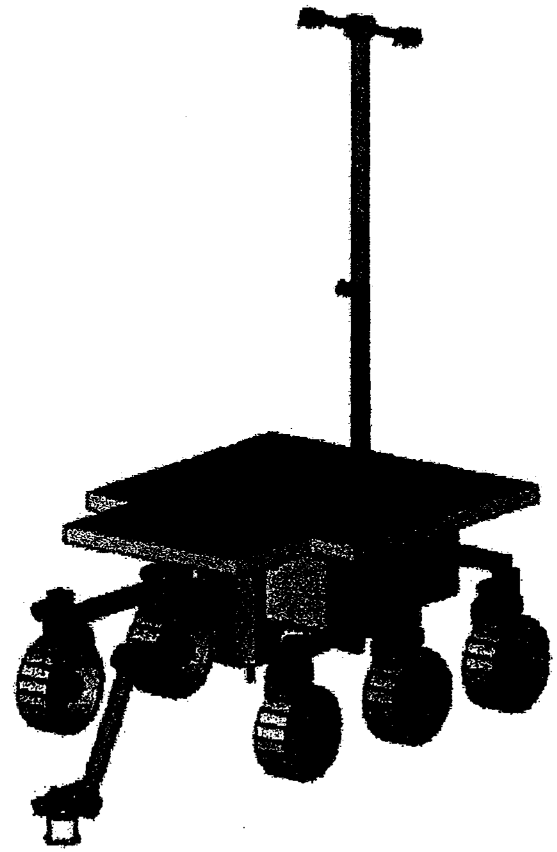
Design features:

- Solar power
- RHU's for thermal control
- Direct-to-Earth communications
- Approx. 100 kg science payload (not including MAV, arm, etc.)



Rover

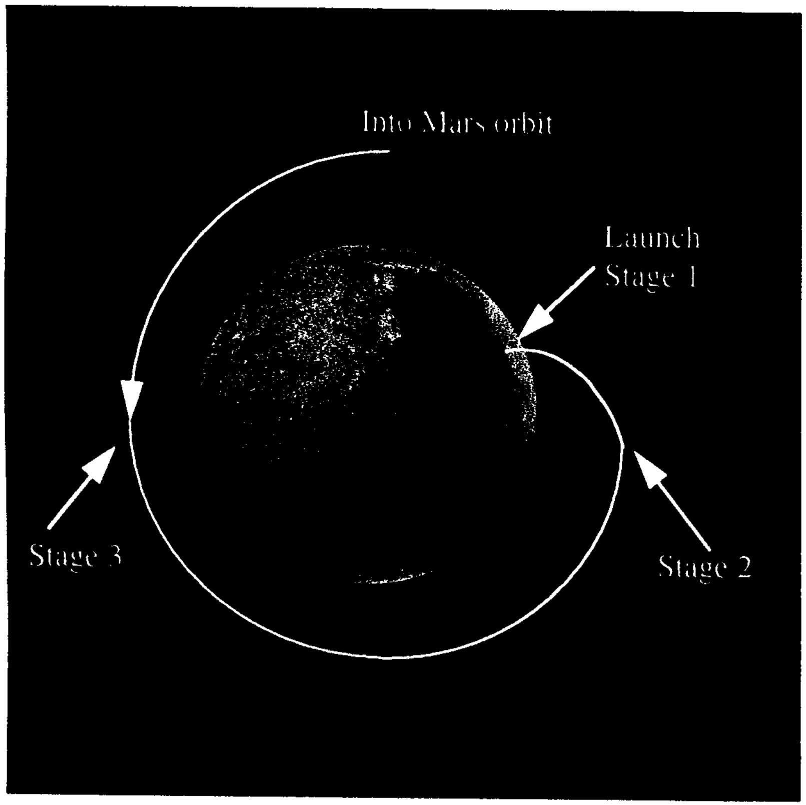
- Athena Payload
- Selects, Collects, and Delivers Sample to Lander/ MAV
- Mass (kg): 100
  - Rover/ Payload 75
  - LMRE 25
- Instruments
  - Pancam/ Mini-TES
  - Arm
  - Microscopic Imager
  - APXS, Mossbauer, Raman Spectrometers
  - Mini-Corer
  - Sample Cache

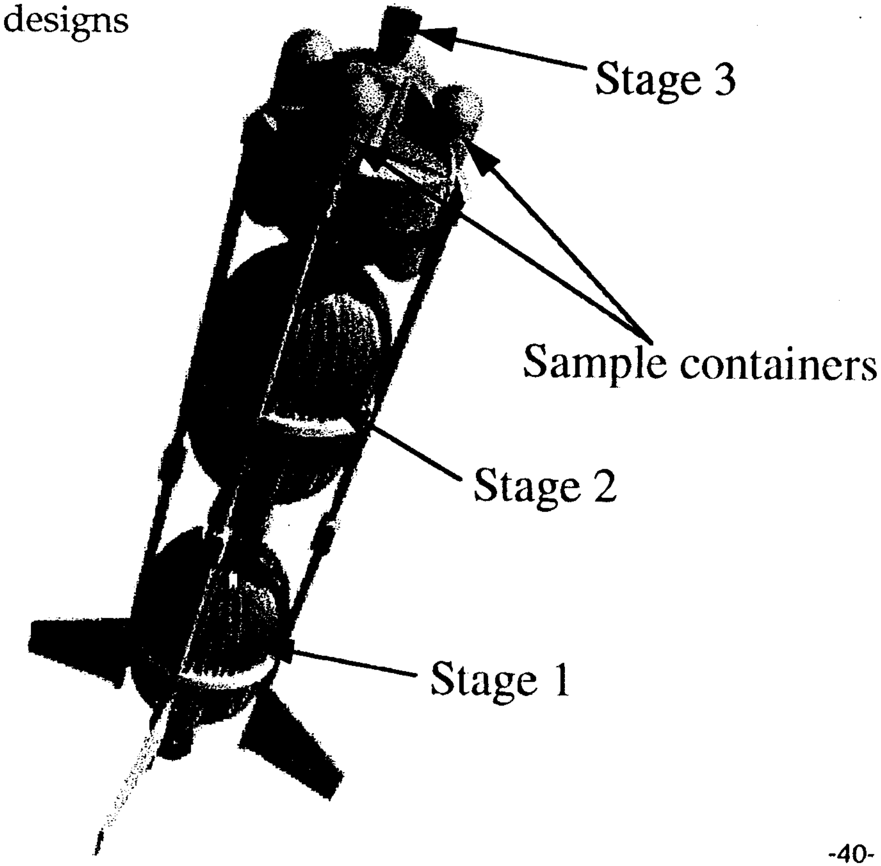


Mini-MAV: The Small Mars Ascent Vehicle

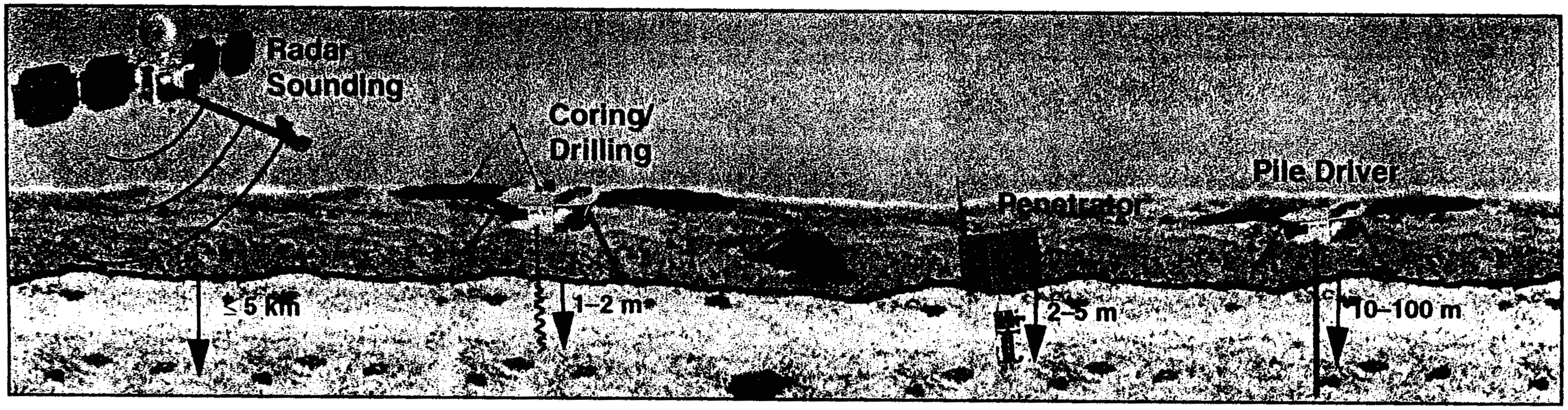
The Mini-MAV represents a new low mass, low cost approach to Mars sample return

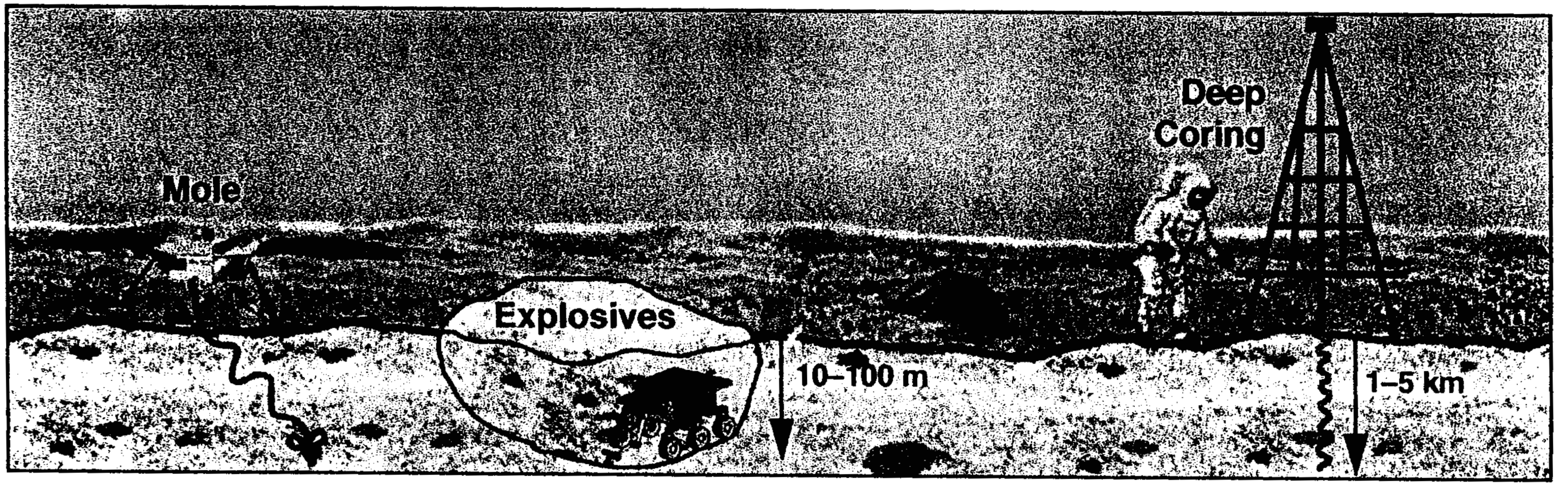
- Concept: Simple solid rocket system with minimal onboard guidance and electronics
- Proven during 1960's Navy test program for launch of small satellites
- 3-stage spin-stabilized ascent system using small solid rocket motors
- Virtually no moving parts, no new technology required
- Total mass approx. 100 kg...less than 30% of previous designs



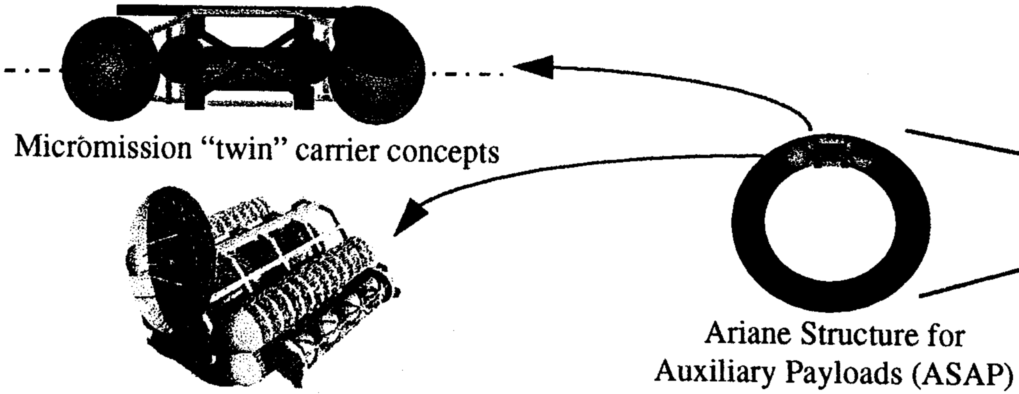


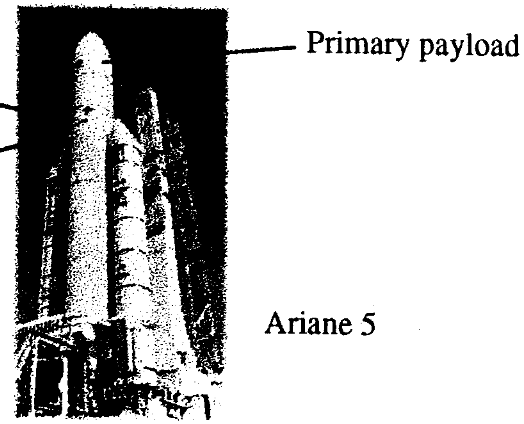
Methods for Accessing the Martian Subsurface



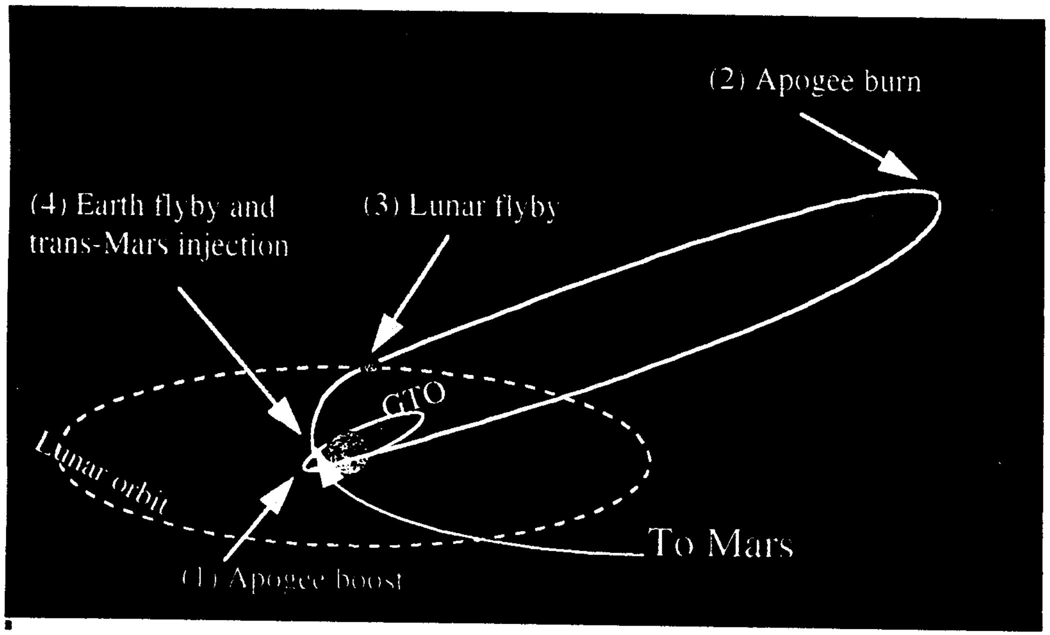


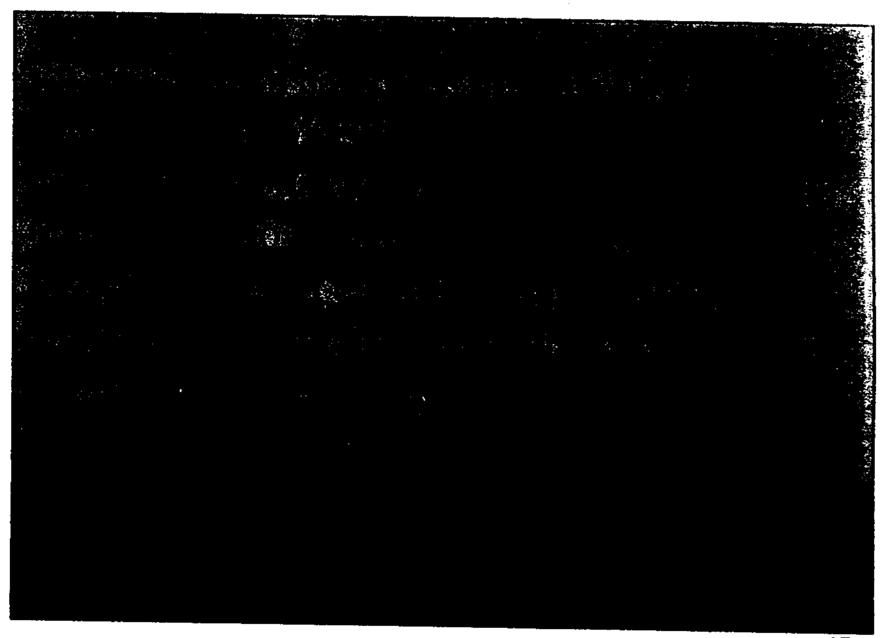
Mars Micromissions Using Ariane 5

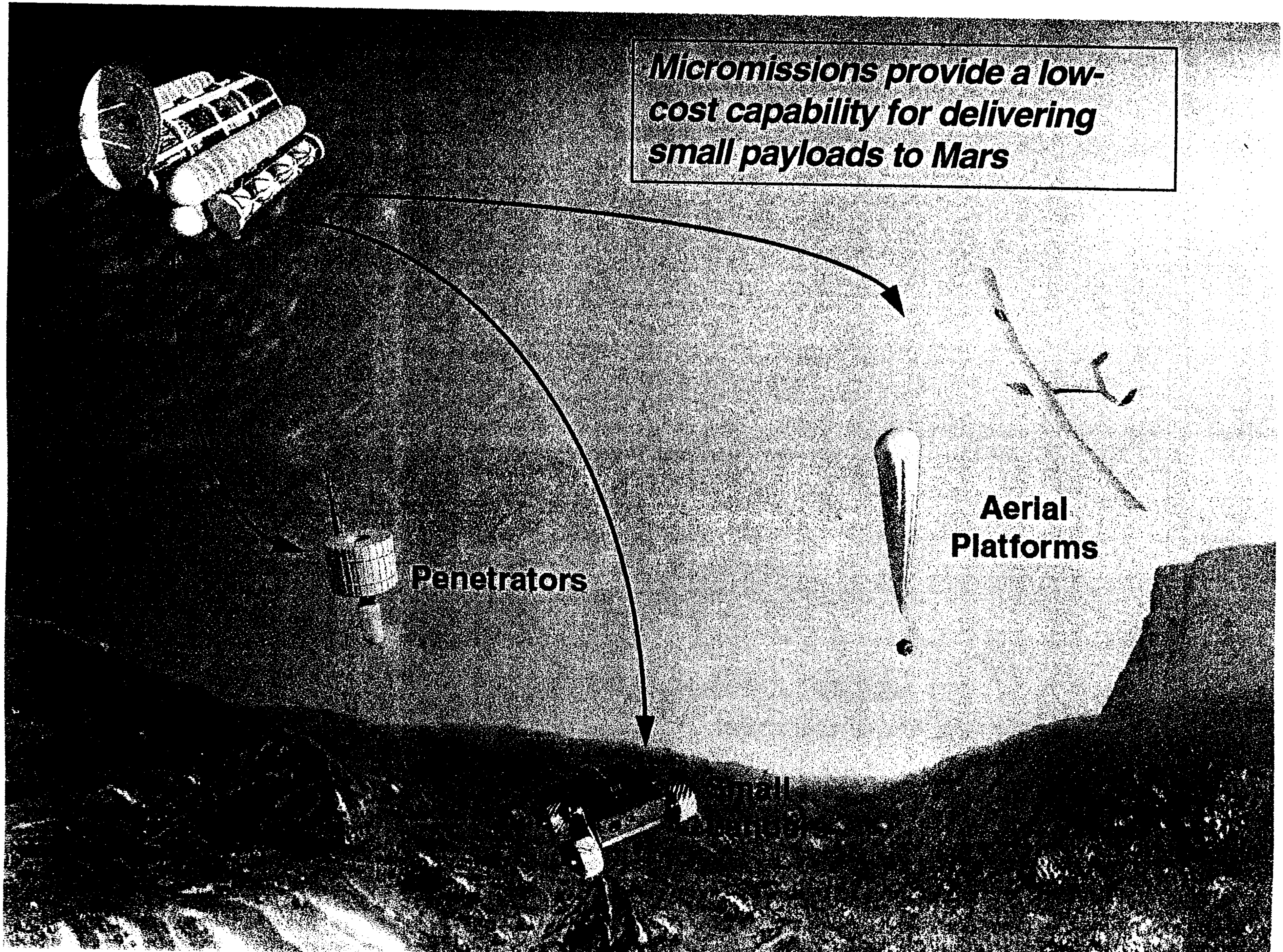




Small "piggyback" spacecraft placed into geosynchronous transfer orbit (GTO) by Ariane 5 can travel independently to Mars






Micromissions provide a low-cost capability for delivering small payloads to Mars
Aerial Platforms
Penetrators

Architecture Team Consensus

Sample Return/In-Situ

- Both sample return and in-situ investigation are essential
- Plan sample return to be received on Earth in 2008 and then in 2012, ...
- '03/'05 Rover will include substantial in-situ capability
- Incorporate additional in-situ and subsurface access capabilities in the '03 lander, '05 lander, '07 lander, and some micromissions to:
  - Verify/test well-thought out hypothesis that some life form exists or not in representative samples
  - Further characterize the surface where the samples were acquired
  - Further understanding of surface properties to help future missions
  - Further understanding of Mars evolution
- Support a program to develop advanced in-situ instruments
- Develop an international approach to acquire the needed tools and sensors
- Develop a "tree/roadmap" for:
  - Type of samples (hard rock, soil, ice, atmosphere, etc. ...)
  - Associated sterilization level
  - Associated acquisition technology
- Strong support for subsurface access capability as soon as possible ('03 if possible). The Italian Space Agency (ASI) might provide this capability in '03/'05 at no cost to NASA

What Made This Architecture Possible

Innovation:

- Mini-MAV (reduced landed mass and cost)
- Orbital caching
- Dual cache acquisition with one orbitor

International Collaboration:

- CNES – major partnering on 2005 launch, long-term orbiters, micromissions, netlanders, and science participation
- ASI – significant partnering in telecommunications, in-situ assets (drills, arms, landed package) and science participation
-

Integrated System Approach / Program Perspective